e-Road Písek - Deggendorf

Analysis of the environmental impact of e-mobility and sustainable development

Project #93

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Content

The impact of e-mobility on the environment in municipalities

Advantages

The electromotor, which is powered by an electric motor, has several advantages over traditional combustion engines. It is not simply a start-up but also a structure that does not need to include components such as gearbox, differential, or drive shafts. Operation is easier as well, since there is no need to replace process fluids, lubricants or filters. Thanks to the simpler construction, the electric vehicle is also lighter and the more compact engine can be placed in the wheels (Pechman, 2016). These properties allow electric vehicles to move with

better dynamics (Moravec, 2017).

While there are many debates about emissions, and the extent to which electric cars are directly and indirectly involved in them, it is important to recognize that electricity can be produced from renewable sources, thus reducing the impact on the air. Nowadays, however, there is little probability in the Czech Republic that electricity used to drive electric cars comes from renewable sources. It should therefore be noted that although an electric vehicle may be powered by, for example, coal or gas power plants, emission production is shifted to power plant areas alone, so that there is no air pollution, for example in cities (Pechman, 2016).

1 - How Does an Electric Car Work? | Tesla Model (Youtube)

Due to the current crisis of deteriorating air and noise quality, electromobility is a suitable solution for cities and agglomerations, as it can contribute to cleaner air and thus generally promote a better health style of the population (Janoušek, 2014).

The reason why electrically powered vehicles are suitable for urban passenger and public transport is lower performance, in which the electric motor can operate at least as well as a traditional combustion engine. The electric motor is able to operate at a very wide range of speeds fluently and for maximum performance, enabling it to cope with sudden and sudden load increases that are characterized by traffic in the urban environment. And since the engine only runs when the vehicle is moving, it saves energy when stopped (Pechman, 2016).

Thanks to these features, the electric drive is a very suitable solution for public transport. The routes covered by the daily buses are characterized by short journeys, which in most cases do not exceed 150 km, as well as frequent stops. As buses often build and start, the possibility of recuperation is also an advantage. In addition to self-charging during operation, it is also possible to charge the electric buses outside the depot, for example at individual stops. (Pechman, 2016).

The great benefits of electromobility are also recognized by national level management in the "National Action Plan for Clean Mobility". The main objective in this area is to reduce the environmental impact of transport and reduce dependence on liquid fuels. State aid should include, for example, various benefits for e-car owners (Jungwirth, 2017).

Especially in large metropolitan areas and agglomerations, electric vehicles have a great advantage in reducing the outside temperature. Traditional combustion engines do not use much of the energy and release it as heat. This problem is largely eliminated for electric vehicles. Calculations for Chinese Beijing have shown that the city could cool down by 2 °C if the electric switchover occurred (Zielinski, 2015).

Summary

- High efficiency and maximum performance over a wide range of revolutions with maximum torque as low as possible
- Easy handling and maintenance
- Easier construction of the engine placed on the wheels
- No need to take care of a large number of components and fluids
- No direct emissions
- No noise
- Possibility to power electricity from renewable sources

Disadvatanges

As has already been said, the production of emissions is now also associated with electric vehicles, because there is not yet such a sophisticated distribution network that relies on renewable resources. Generally speaking, there is only a small proportion of renewable power plants in the Czech Republic.

Another big problem now is the price of electric vehicles, be it bikes, scooters, cars or buses. The high financial demands are due to the expensive technologies needed for battery technology.

A big burden is also the heating or air conditioning of the car, which significantly affects its range. These functions, without which today's vehicles can be, are a load of 10% charged capacity, which means that short lines can handle vehicles, but the quality of customer care would deteriorate on long routes (Pechman, 2016).

When we talk about vehicles that have internal energy storage, it is also a matter of charging and battery life. It is more convenient for current users if the vehicle is charged as soon as possible, but in the long run this approach in most cases means a reduced battery life. Due to the demanding recycling and disposal of discarded accumulators, this disadvantage is also due to electric vehicles (Pechman, 2016).

Recently, there have been many reports in the media on state support for electromobility in Norway, which has led to a rapid increase in sales of electric passenger cars. Although the Czech Republic currently has a national action plan on clean mobility, state support is currently lagging behind other countries, which is one of the reasons that prevent the growing popularity of electric vehicles.

It is also known from the general description of the construction of the accumulators that if it is damaged, poisonous substances and metals that are used in the production process get into the vicinity. In an extreme situation, articles may also ignite (Moravec, 2017).

The big obstacle today is also the short range of electric motors that currently cannot compete with traditional combustion and compression ignition engines. From an economic point of view, it is paradoxical to purchase a car with a short range, but the technology is very expensive. The competitiveness of electric vehicles comes with the progress that is currently being made in battery technology and in increasing range, but also, for example, the battery charging time (Moravec, 2017). With the development of these technologies, there will also be an increase in the number of electric vehicles produced, which will also help reduce costs through large-scale production savings (Augenstein, 2015).

Summary

- Emission production when charging vehicles
- High purchase price

- Energy performance of interior functions
- Battery life limited
- Insufficient public support
- Short rangeRequirements

When it comes to the requirements for a well-chosen electric car, it is important to focus on the following areas

- Battery type
- Drive type
- Vehicle size
- Relief
- Type of routes
- Charge options

Thanks to the correct specification, the vehicle will not only be optimally burdened, but also meet environmental and noise standards, making it suitable for operation in, for example, historic city areas (Pechman, 2016).

If cities want to profile their sustainability and Smart City approach, then pure mobility is one of the pillars on which to build.

2 - UN/DESA, Development Policy and Analysis Division

It is necessary to create a public transport network to help not only reduce the environmental impact, but also to help reduce the number of vehicles on the road (World Economic and Social Survey, 2013). The focus should therefore not only be the renewal of the fleet, but also public events to promote the spread of awareness and the possibility of alternative means of transport within the city.

Technical Solutions

Currently, several manufacturers focus on the production of electric buses.

Brand	Model	Range
Siemens	Rampini	100 km
	Solaris	260 km
Libchavy a Cegelec	SOR EBN 11	150 km
	SOR EBN 9,5	100 km
Skoda	PERUN HP	30 km
	PERUN HE	150 – 200 km
	E´City	-
VDl Bus & Coach	VDL Citea SLFA Electric	270 km
Ursus Bus	Ekovolt	120 km
	City Smile 8.5	150 km
	City Smile 10M	-
	City Smile 12M	-
	City Smile 18M	-
BYD Auto	BYD K9	250 km
Alstom	Aptis	-

3 - List of Electric Buses

Charging

Siemens-RAMPINI

Jechort shows that "[when charging, the vehicle is connected by a two-pole single-armed current collector to a short trolleybus type two-track line that is fed from a nearby traction distribution system (metro, tram or trolley)" (2016). Because the vehicle is powered at regular intervals for a maximum of 15 minutes, the electric bus can easily drive off a day's shift. There is plenty of electricity in the car to keep passengers comfortable and use heating or air conditioning (Jechort, 2016).

Siemens-SOLARIS

Two charging terminals located in Hamburg (one in the city center, the other in the Alsterdorf district) each have a capacity of 300 kW and have two charging stations. These e-buses will provide enough energy to last the day. Charging is very fast, it takes only 6 minutes. (Siemens, 2016).

SOR EBN 11

Bureš explains that "to ensure the necessary daily range […], the recharging will take place via a two-pole pantograph on the roof of the vehicle from a short section of a specially built trolley bus" (2015). The vehicle is therefore charged for up to 7 hours overnight, but also during the day when fast charging is involved (2015).

PERUN HP

Skoda utilizes "high-density batteries [which can be used to charge the car in 5-8 minutes" (n.d.) using the ŠKODA Ultra Fast Charger. For these vehicles, it is possible to choose charging at both end and intermediate stops (Skoda, n.d.).

PERUN HE

This type of car is only recharged at the end stop in two ways - during a night's rest in approximately 8 hours, or with a quick charger that reduces recharging time to 70 minutes. The bus is equipped with standard Li-Pol batteries (Skoda, n.d.).

VDL Citea SLFA Electric

This type of car can be recharged at end stations by charging stands or in garages. The capacity of this 18 meter bus is 122 kW (Československý dopravák, 2017).

Plug-in

There is also a way to replace batteries for the needs of electric buses. This reduces the time required for recharging because batteries are recharged off the bus. It is therefore possible to recharge in the most optimal way to extend the battery life, as the battery is not subjected to shock charging. Also, recharging may not be as costly as the rechargeable batteries can be recharged off-peak (Pechman, 2016).

Slide-in

This principle means recharging the batteries for the duration of the journey, thanks to the induction and specially adapted road that allows recharging. The road is not so modified along its entire length, so charging occurs at certain intervals (Pechman, 2016).

Traditional Transportation Externalities

Nowadays, cities are struggling mainly with the problem of air pollution caused by vehicles of all kinds. Not only does the quality of the environment deteriorate, but the immunity and health of vulnerable populations, such as asthmatics and allergy sufferers, also deteriorate. This pollution not only affects the respiratory tract but also the cardiovascular system, and in some cases gene mutation may also occur in fetal development.

As the transport infrastructure has been built at a time of less capacity, congestion often occurs, which has a negative impact on the psyche (Jungwirth, 2017). People are often exposed to stress when traveling to school or work, which puts a heavy strain on their mental health, which also affects physical health.

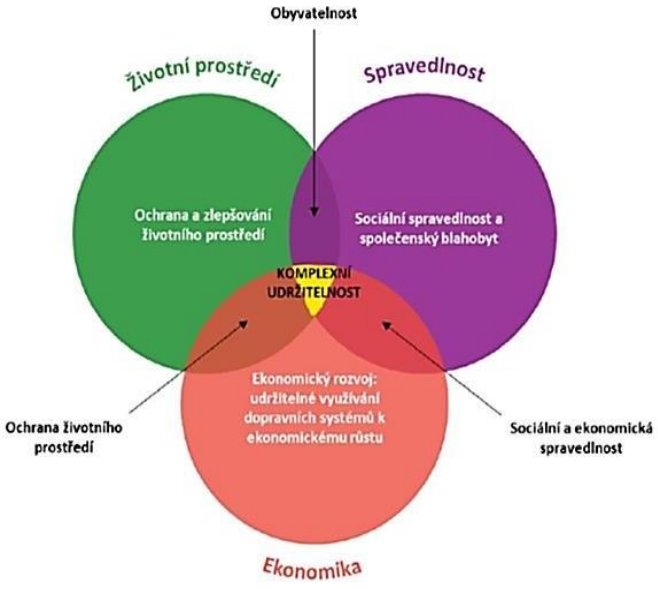
The main pollutants are

- Dust (PM including nanoparticles) released during braking (Carrington, 2017)
- Aerosols
- NOx
- Ground floor O3
- Hydrocarbons
- Noise
- Traffic jams

These not only cause deterioration in the health of the population and the environment, but also cause costs associated with health care, construction and material damage, crop loss, and damage to ecosystems (Ayalon, 2013).

Recommendations

It is not the intention of sustainable measures to ban the use of passenger cars, as this would be both difficult to achieve and, on the other hand, contrary to democratic principles of freedom and choice. The idea is to design and manage urban space in such a quality and scale that people no longer need a car to move around in the city. One of the basic requirements is quality infrastructure, which needs to be sufficiently funded (Klímová, 2016).

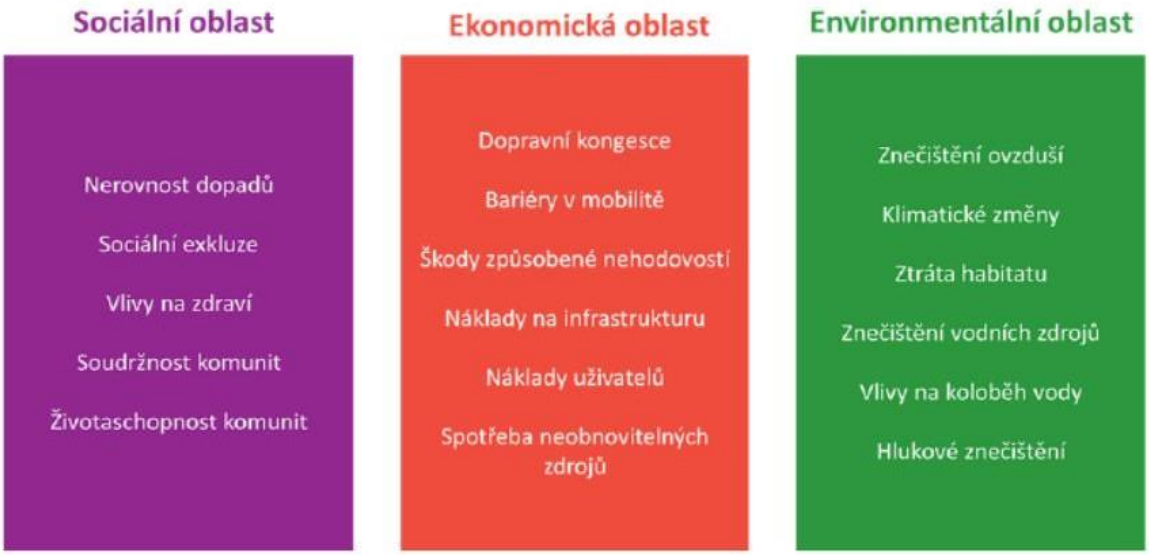


4 - Complex Sustainability Principles (Jungwirth, 2017)

When buiiding or adjusting the infrastructure, it is necessary to think about the various aspects of the environment, such as relief, weather, usage time. Infrastructure must adapt not only to the requirements of the city and the population, but also to the natural conditions and capacity of electric cars. The example from Prague shows that the hilly terrain combined with extreme winter weather are not the best

conditions for using only electric buses, because current cars are not able to cope with these conditions.

Therefore, in the near future it is not possible to consider the complete replacement of the city car fleet, but electric cars can gradually become a full complement of buses for both traditional and alternative drives. This option is particularly useful in an environment that is more sensitive to air pollution, such as the city center, the historic area, or the tourist spots. The advantage is not only the reduction of emissions but also noise pollution (Hruda, 2017).



5 - Detailed Complex Sustainability Principles (Jungwirth, 2017)

One of the main steps is to integrate clean mobility into the city's strategic documents. In addition to the city's goals, it should also be steps to promote the ownership of cleaner vehicles. For example, different levels of taxation can effectively manage transport demand as it encourages regime changes and can be a good source of revenue.

The annual tax offers more flexibility than sales taxes, because tax rates can be altered over time and the burden is imposed on vehicle owners for a longer period of time. Different features could be incorporated into vehicle taxation according to different transport strategies.

For example, taxation could be done according to vehicle type, vehicle price, vehicle size, emissions and noise levels. The established systems used in Sweden and Germany support the ownership of low-emission vehicles.

The next step is to support night supplies. It is possible to train people, work more quietly and ask carriers to attach noise abatement equipment to transport vehicles, as Barcelona has done in a pilot project that has become national. With night supplies, suppliers can drive larger trucks on less congested roads. Cities would be able to reduce congestion and emissions in this way (Hannon, 2016).

One way could also be to promote the sharing of vehicles. Currently, this concept is under development and is being tested in some places, so it is hardly possible to make a general conclusion.

In addition to the modes of transport themselves, it is also important to adjust access to urban planning. Cities should focus on adjustments that support an environment that combines integrated and urban transport, thus reducing the use of passenger cars in urban areas (Kandt, Smith, & Graff, 2015).

Influence of e-mobility on living organisms

Noise

One of the main questions is the lack of noise typical of electric vehicles. The electric motor is very quiet and the car emits sounds only in connection with wind flow and wheel movement. This problem is particularly noticeable at low speeds, as the traditional "whistle" of the engine adds to the above-mentioned sounds at higher speeds.

Some countries, such as the US, have already incorporated into the legislation the necessity of providing low-speed noise to the electric vehicle. In addition, it is important that cyclists and pedestrians, including the blind, have the opportunity to register an electric vehicle, and a certain level of noise is also needed to protect animals.

An American university study has shown that it is still necessary to adjust this new legislation because the limits must not only be on the minimum noise level but also on the maximum. For example, birds are disturbed by the daily routine if car noise is too high (Nunez, 2015).

But for animals living on the ground, it is important to realize that their reflexes when arriving on a vehicle are in most cases frozen on the spot or plunged under the wheels. But if the animal is healthy, in most cases, it avoids the vehicles, which cannot be said about pedestrians who are busy with different activities and therefore rather follow their hearing.

The experience of electric vehicle owners shows that the lack of vehicle noise is not a big problem for animals and the reaction is very similar to any other vehicle (Are electric vehicles more dangerous to pets and wildlife close to roadways ?, 2017).

Pollution

Major causes of environmental pollution include heavy metal discharges, persistent organic pollutants, toxic substances, but also smog, particulate matter and ground-level ozone. Traditional air transport emits many of these substances or contributes to the formation of negative phenomena (acid rain). These substances come into the body of animals from both the air and the food chain. First, they can act like humans and cause health problems in the respiratory and cardiovascular systems. Secondly, these substances accumulate due to the advancement of the food chain, thereby affecting the quality of the food, while at the same

time much more animals are affected than those that have occurred near the discharges of these substances (Canadian Government, 2012).

Pets may suffer from tumors or heart attacks due to air pollution. Amphibians can change their behavior through its influence and, like humans, suffer from reduced immunity. Birds suffer not only from the deterioration of their respiratory system, but also from their food death and mercury accumulation. Changes in water pH kill fish species that are sensitive to pH fluctuations. Insects can migrate due to pollution, changing the entire original ecosystem (Watts Hull, n.d.).

In the context of direct emissions, electric cars are set to 0. Thus, they do not cause any contamination in the immediate vicinity, ie except for the discharges of particulate matter during braking (Carrington, 2017). Therefore, their environmental impact is minimal in the area where they are moving.

But when it comes to total emissions, which are also associated with vehicle production, emissions are currently being produced in the production of electric vehicles. The question is also the source of the electricity used for the drive. There is currently only a small percentage of renewable energy plants in the Czech Republic. Thus, although electric vehicles do not produce any direct emissions, they still have an impact on air quality in production and disposal.

Hazardeous Watte

The biggest environmental issue is batteries. They contain a lot of chemicals, especially elements such as lithium or cobalt, which can be disposed of in the groundwater to poison aquatic animals. Also, the battery may be perforated, causing toxic substances to leak into the environment (Gardiner, 2017).

It is also a great fear of storing old batteries in landfills, causing contamination of the environment. Nowadays, lithium is mainly used in consumer product flashlights, which often end up in this way. In some countries, however, legislation is already in place that obliges electric car manufacturers to look after the old battery. There are several start ups around the world that focus on recycling electric car batteries. Some manufacturers are also trying the best way to reuse these batteries, for example, as batteries in homes (Sanderson, 2017).

The longer the life of an electric car, the less its adverse impact on the ecosphere, because much of the toxic side effects are related to the production of the electric car, especially the battery life cycle. Furthermore, the level of toxicity in natural water sources and their excessive eutrophication, ie nutrient supercharging and the effect of this supercharging on algae.

Polutant	Ecology Impact	E-Mobility Impact
SOx, NOx (European Environment Agency, 2016)	• Accumulates and acidifies the environment • Causes acid rain • Deteriorates food and carbon processing • Impaired access to water (UNECE, n.d.)	• No local exhaust emissions (Bentzen, Bezdzietna, Krasteva, & Laugesen, 2014) • Pollution depends on the type of power source (European Environment Agency, 2017)
Ground ozone (European Environment Agency, 2016)	• It destroys plant cell membranes, thereby preventing their development • Deteriorates the ability of flora to clean air (UNECE, n.d.) • It weakens crop quality (European Environment Agency, 2016)	• The worst choice for a non-organic power source (Johnson, 2017)
Particulate Matter (UNECE, n.d.)	• Associated with higher mortality and cardiovascular problems (Environment and Climate Change Canada, 2013) • Storage of heavy metals in the soil • Changing the Amount of Light Possible to Use in Photosynthesis (Biswal & Mohapatra, 2014)	• Only less dangerous PM10 compared to PM2.5 from diesel fumes (Biswal & Mohapatra, 2014)

Noise (UNECE, n.d.)	• Reduced variation of bird species in nesting sites (Cruz, Francis, & Ortega, 2009) • Negative impact on sleep quality, long term memory and concentration (Matheson & Stansfeld, 2003) • Animals cause disorientation, increased aggressiveness, loss of sound and inefficiency in hunting (Rankesh, n.d.)	• Quieter Vehicle Operation (2018) • Necessity of Artificial Volume Control and Legislation (Office of Technology Assessment at the German Bundestag, 2012)
Alien Organisms (UNECE, n.d.)	• Threat to biodiversity and human good • High costs of health costs associated with foreign organisms environmental or landscape Disruption (Ascensao & Capinha, 2017) • Extracting animals from a suitable natural environment (Beja, Catarino, Godinho, Marques, & Mira, 2017)	
Hazardeous Waste	• Car repair shops work with various toxic materials they have to process (Zdrazil, 2013) • Aerosol containers with cleaners, airbags, antifreeze, cleaners and solvents, wastewater, oils and lubricants, liquids (Wisconsin Department of Natural Resources 2017)	• Electric cars • do not need handling of toxic materials because they do not contain engine oil and similar lubricants (Zdrazil, 2013) • Insufficient recycling of substances contained in batteries (lithium) (Gardiner, 2017)

6 - Influence of Pollutants and E-mobility on the Environment

The impact of e-mobility on ekology

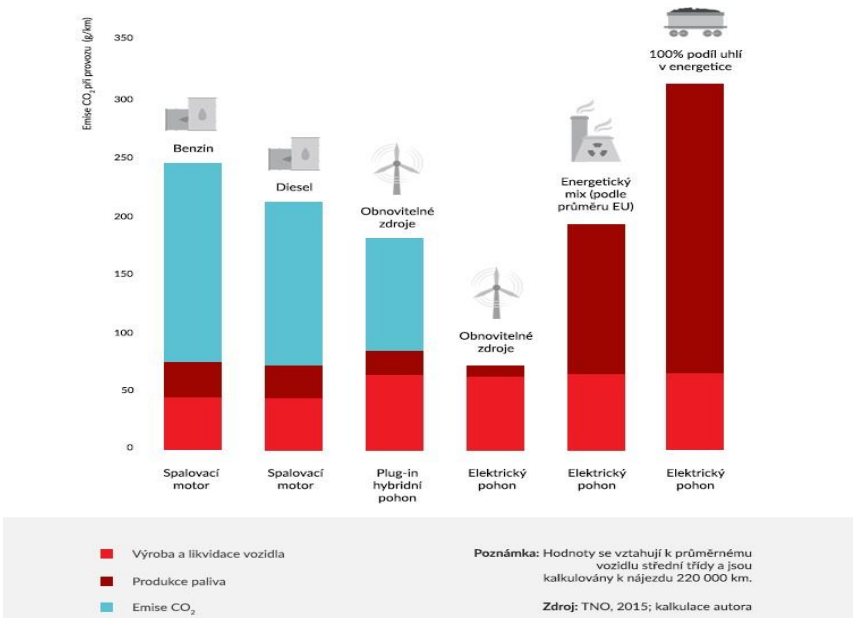
Over the past twenty years, the company has become interested in ecology and sustainable development. The rise in oil prices, concerns about the depletion of its reserves and the wider awareness of the negative environmental impacts have made humanity slowly shift to alternative sources. Renewable resources are driving out traditional non-organic fossil fuels.

Electric vehicles seem to be very effective and their seemingly undeniable advantage lies in zero emission production. However, this approach is partly mistaken. There is a need to distinguish between direct and indirect emissions.

Direct emissions: operating emissions are really zero. There is no production of pollutants during the operation of the electric motor, electricity is only consumed and partly produced. Unlike internal combustion engines, where fuel is burned and harmful gases are released into the air.

Indirect emissions: total indirect CO2, NOX2, SO2 PM emissions depend fundamentally on the country's energy mix. Emissions generated by power plants themselves in electricity generation. (Konecny, 2015)

Electric vehicles are more environmentally friendly than cars with internal combustion engines. Differences may increase or decrease depending on the energy used. This fact points to another sad fact, which is the production of electricity. Most of the world's electricity is obtained by converting fossil fuels, a process where vast amounts of CO2 are released into the atmosphere. Especially because of this, electromobiles often seem less ecological than we would expect. But it is not their merit. If most of the energy was obtained from renewable sources, nature would be saved not only in the energy production itself, but also in the operation of electric vehicles. (Dolejs, 2017).



7 - Emissions Depending on the Type of Fuel Source (Švarc, 2017)

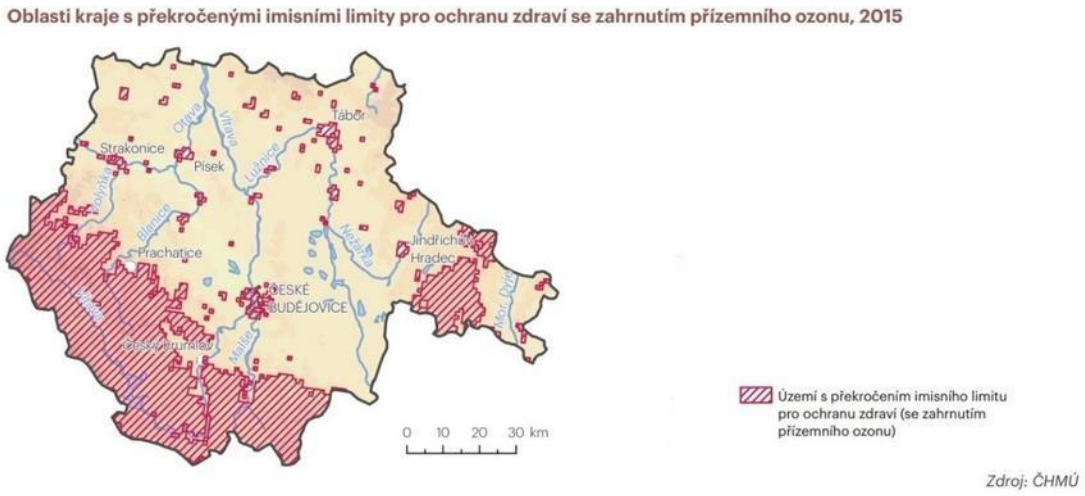
Air Quality

Scientists have calculated that diesel cars produce almost 4.6 million tons of Nox more per year than was the case for manufacturers to comply with applicable emission standards. This is evidenced by a report entitled Air quality in Europe, which sets out the 2013 figures. According to it, the solid particles inhaled by every human being, which are mostly involved in diesel engines, and especially microparticles below 2.5 microns, are the culprits of 436,000 deaths. Blame for polluted air, especially in the Czech Republic, but not just diesel cars. Large-scale coal-fired power plants and obsolete household fireplaces have a large share. (Hybrid, 2017)

The South Bohemian Region has long been one of the regions with good air quality, but these include areas with deteriorated air quality, which are České Budějovice, Písek, Dačice, Strakonice, Vodňany and Tábor. Significant emissions are concentrated on major road communications. In Tábor, the limit value for PM10 particulate matter was repeatedly exceeded, and in České Budějovice the limit for polycyclic aromatic hydrocarbons (PAHs) was also exceeded.

Increasing airborne dust concentration is currently one of the biggest air protection problems in the Czech Republic. Emissions of pollutants from transport in the South Bohemian Region had a decreasing tendency in the long term due to the modernization of the car fleet; however, this decreasing trend has been stagnating recently due to the increasing road freight transport. However, there is a clear increase in greenhouse gas emissions caused mainly by the increase in road transport performance.

Electric vehicles are the right way to minimize the traffic on vehicles. However, the problem with the power generation itself, which currently produces a large amount of pollutants for our nature, must be resolved. Only then does the operation of electric vehicles make the most sense. The imaginary sticks are thrown by electric car manufacturers and companies that benefit most from fossil fuels. Not all studies are based on truth and deliberately damage electric cars to delay the onset of electric power in cars. (Dolejs, 2017).



8 - Regions with Exceeded Imission Limits (CHMU, 2015)

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Electric vehicles do not produce exhaust gases by their operation, and even with the production of electricity from conventional sources (eg brown coal), their environmental impact is usually better than for cars with internal combustion engines. CEZ expects that in 2020, electric vehicles recharged from the normal network will be indirectly discharged by 73 % less CO2 emissions (44 g / kWh) than conventional B-segment cars (164 g / kWh). In 2008, it was 42% less (95 g / kWh). They are very quiet and have low running costs. Energy for batteries can be obtained from renewable sources, thus with a very low carbon footprint. (Reznicek, 2016).

Over time, electricity becomes more pure as advanced countries switch to renewable energy. In a study, Dr. Maarten Messagie concluded that, even if it existed the space for improvement in battery production to reduce the environmental impact of electromobiles has a more favorable impact than is generally said. (Drive, 2018)

The longer the life of an electric car, the less its adverse impact on the ecosphere, because much of the toxic side effects are related to the production of the electric car, especially the battery life cycle. Furthermore, the level of toxicity in natural water sources and their excessive eutrophication, ie nutrient supercharging and the effect of this supercharging on algae. (Vachtl, 2012).

Disadvantages of e-mobiles on the environment

The analysis of the impact of electric vehicles on the environment can be divided into two parts:

"From source to tank" (WTT), assesses energy performance and greenhouse gas emissions in phases that prevent final fuel consumption in the vehicle.

"From Wheel Tank" (TTW), balances energy consumption and greenhouse gas production in the vehicle's final fuel consumption phase.

Together they include the entire life cycle (WTW) (Janoušek, 2014).

The impact on the environment is certainly not only driving with a vehicle, but also its production, disposal, mining of material for the production and acquisition of electricity. Electric vehicles contain noticeably more precious elements, which were mainly provided by batteries. These are the reasons why the overall production process produces more CO2. (Dolejs, 2017)

For some "green" products, I get the impression that industry lobbyists and corporate marketing departments are abusing environmental protection to increase production and profits. (Dobias, 2015).

Other impacts

Another example of eco-innovation with a very unclear environmental benefit is the bio-component that has started to be added to gasoline and diesel to reduce greenhouse gas

production and reduce oil consumption. The biocomponent is produced from biomass (mostly oilseed rape) and is currently about six percent in petrol and diesel. In the future, its share should increase further. By 2020, biofuels should account for a 10% share of the European Union's requirements. Rapeseed fumes are more damaging, crushing and massive monoculture seeding disrupts the natural ecosystem

Before mankind solves the fuel crisis and electric cars dominate the roads, we can expect the carmakers' endeavor for more fuel-efficient gasoline engines and cleaner diesels. There may even be some merging of the two concepts: a turbocharged, directly injected petrol engine capable of burning lean. Or is there a way in hybrid drives? This concept also carries considerable pitfalls (Stýblo, 2010).

The most vulnerable categories

- Soil and water acidification (TAP) - eg acid rain has a similar potential in the production phase for both electric vehicles and internal combustion engine vehicles.
- Particle Generation (PMFP) - Electric vehicles using natural gas electricity are doing their best because of the purity of natural gas and complete combustion.
- Photochemical Smog (POFP) - here the electric cars are doing their best. "With a European mix of electricity and gas, they allow a reduction of 22-33% compared to ICEV."
- Human Toxicity (HTP) - the most vulnerable category of shifting problems to other areas of transition to electric vehicles. It is estimated that HTP will increase in both the production phase and during operation of electric vehicles. "According to the EV type, HTP is expected to have a 180-290% impact."
- During the production phase, toxicity is caused by the consumption of copper, nickel and lithium. Mining and processing these compounds require considerable energy. During these processes, toxic substances can be released that can contaminate the air and water.
- Soil and aquatic toxicity (TETP) - caused largely by zinc emissions (40%) arising from brakes from tires, copper and titanium (25%). There's no big difference between cars.
- Mineral depletion potential (MDP) - a problem of lack of individual metal reserves.
- Potential depletion of fossil fuels (FDP) - The use of electricity produced from natural gas or hard coal will not lead to a significant reduction. (Janousek, 2014)

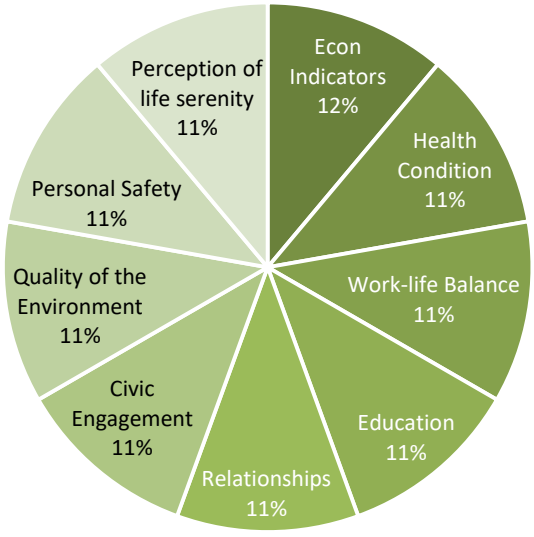
The operation of electric vehicles has a lower environmental impact on some vulnerable categories than conventional vehicles, but in the end these differences are offset by the additional burden of electric vehicle production. The ecological way of producing electricity and using it is the only significant benefit during its operation. RES reduce the impact of global warming and the fossil fuel depletion potential.

Assessing the impact of e-mobility on the quality of life of residents

The United Nations survey shows that by 2050 68% of the world's population will live in urban areas (United Nations, 2018). Given the current problems that metropolitan areas are flooding, one of the most problematic areas of which is the environment, it is now necessary to look for the most effective solution. Given the great potential of electromobility in the clean environment, this industry is likely to be one of the major ones to come to mind when it comes to improving living in residential areas.

The generally accepted definition says that a settlement is a "settlement unit that forms a closed, spatially separated unit from other settlement units" (Department of Urbanism and Planning, n.d.). Settlement units are divided into rural and urban according to several criteria (Church Elementary School Veselí, n.d.). Given that residential areas are the center of life and will increasingly become a larger part of the population, it is clear that there will be problems that will not improve the lives of the population. The quality of life in the Czech Republic's 2030 Strategy Paper is measured by more indicators than economic indicators.

In relation to electromobility, we can talk about the following categories: economic indicators, health status, environmental quality and culture. The strategy suggests that sustainable development is at the heart of the strategy, and electromobility is a prerequisite, especially given the strong emphasis on increasing the percentage of energy produced from renewable sources across the EU.



9 - Quality of Life PErspective (Office of the Government of the Czech Republic, n.d.)

Economic indicators

The main aspects are transport itself, because the quality in residential units is determined mainly by the construction of transport infrastructure, which is the basis for the proper growth of the city (Kladivo, 2011). Cities around the world are slowly beginning to accept restrictions on the entry of internal combustion engines into the centers, thus disrupting transport continuity. However, since electric cars do not exclude any direct emissions, these restrictions will not apply to them, so they can ensure uninterrupted transport, be it passenger electric cars or electric buses.

In the field of economy, the 2030 strategy also places emphasis on low carbon technologies and quality infrastructure. This approach is associated with the efficient use of energy and energy resources (Government Office of the Czech Republic, n.d.). Electric vehicles do not produce any emissions directly, so if they are low-carbon infrastructure, then electric cars are one of the cleanest options. But it is true that there is currently no electricity network mainly from renewable sources, but emissions are shifted from cities to power plants.

The report on the impact of electromobility on the economy concluded that the development of the electromobility market can lead to a significant increase in jobs - in countries like the US, Germany and the Netherlands, tens of thousands are counting (Mol & Munnix, 2016). Variation within the industry is part of the economic cycle, and new technologies that are associated with the production and operation of electric vehicles, especially in battery technology, will help create new jobs. In the Czech Republic, several universities are involved in the development of electric vehicle technology.

Electromobility not only has an impact within its sector, but also the energy, information technology and education (Mol & Munnix, 2016) will benefit from the flexible use of electric vehicles, especially batteries. Hand in hand with electromobility, especially in urban environments, are technologies such as autonomous control and the use of Big Data.

Interestingly, despite the fact that electromobility is perceived as very disruptive to the economy, it cannot be expected to contribute significantly to reducing the number of places in the automotive industry. Conversely, one of the greatest threats is the situation where electric vehicles would not be produced in Europe (Transport and Environment, n.d.). Building on EU objectives, it is clear that manufacturers will look for new ways to adapt their products to the requirements of the new legislation. If electric cars are not produced in Europe, they would be imported from other continents to meet environmental targets. This would harm local carmakers because they would not be able to compete with foreign manufacturers.

As depreciation for second and third vehicle owners is minimal, electrified cars are a good option for lower-income residents due to low operating costs, but they are also a big advantage for drivers driving many kilometers (The European Consumer Organization, 2016) . In the Czech Republic, the market for electric cars is at the beginning, but in the neighboring countries both the first owner market and the following are already in operation. Cars generally lose value very quickly and electric vehicles have the advantage that their

operating costs are minimal due to the many missing components that cause high repair and maintenance costs for conventional cars.

At the same time, electromobility helps reduce dependence on oil imports (Deutsche Gesellshaft für Internationale Zusammenarbeit GmbH, 2013). Reducing the growth of vehicles, reducing travel demand and improving engine performance are also associated with the reduction in oil demand (2011). Europe is currently facing a strong dependence on oil imports, which is not the best position given the instability of the countries from which it imports oil. Electromobility would thus contribute to political and economic stability and would be able to support R&D in the field of efficient vehicle operation, as pressure is now on greater range and longer battery ruptures.

Health condition

One of the priorities of the 2030 strategy is to focus on the impact of pollutants and noise on the health of the population. One of the big contributors to this problem is the petrol and diesel engines (Government Office of the Czech Republic, n.d.). Although it is not possible to get rid of the contamination of solid particles, since they are released during braking, electromobility can provide a reduction of NOx and SOx, since the electric vehicles are emission-free. Electric motors are also much quieter than combustion engines, reducing the noise impact on urban areas. However, almost noiselessness can cause, for example, a problem for pedestrians who often do not hear an electric car, so some electric motors are now equipped to emit quiet sounds that pedestrians can hear but are not as level as internal combustion engines.

Regarding the Spatial Development Policy, one of the national priorities is the higher quality of transport infrastructure with regard to the protection of public health (Ministry for Regional Development, n.d.). In urban settlements, electromobility contributes primarily to zero emissions and low noise levels and increases control over health factors by helping to prevent pollution that cannot be influenced by someone else.

Environmental quality

Direct support for electromobility and the construction of the necessary infrastructure should contribute to ensuring good environmental care, with a strong emphasis on the significantly increasing number of environmentally friendly vehicles (Government Office of the Czech Republic, n.d.). The study of the economic cost of electric vehicles has shown that electromobility can make a significant contribution to reducing CO2 emissions within the transport industry from an environmental perspective (Schmelzer & Miess, 2015).

Culture

The cultural landscape is specified by a combination of natural and cultural influences (Mendel University in Brno, n.d.). There is a passage in the Constitution of the Czech Republic that states that citizens are committed to protecting and promoting the development of, inter alia, cultural wealth. But this is difficult to achieve when historical centers are flooded with exhaust fumes and noise from passing cars, but also trucks and public transport.

How does electromobility contribute to sustainable development?

According to the conceptual strategy of the Climate Protection Policy in the Czech Republic, it is assumed that by 2035 it is possible to reduce emissions most due to standards for cars and fuels, and the improvement of public transport (Ministry of Environment, n.d.) will also play an important role. Several cities are already incorporating the use of electric buses in their transport strategy, and in many places electric car owners have benefits such as reduced parking fees.

Legislative tools

Electromobility also plays a part in programs that promote vehicle efficiency. The table shows examples of measures that apply in the world.

Tool	E-mobility Role

Fuel Consumtpion Optimization (The Innovation Center for Energy and Transportation, 2011)	• HEV
	  ○ By calculating the computer, the ICE and battery connections are adjusted to make the most economical driving (Ergon, n.d.)
	• PHEV
	  ○ Can only run on electric drive and ICE is for extended range or power boost (Ergon, n.d.)
	• BEV
	  ○ Does not use fossil fuels

Greenhouse Gases Emissions (The Innovation Center for Energy and Transportation, 2011)	• HEV
	  ○ Reduced due to the combination of ICE and electric drive - WTW = 6.3 t CO2 compared to 11.4 t gasoline engine (U.S. Department of Energy, 2017)
	• PHEV
	  ○ Reduced due to the combination of ICE and electric drive - WTW = 6.1 t CO2 compared to 11.4 t petrol (U.S. Department of Energy, 2017)
	• BEV
	  ○ Without direct emissions - WTW = 4.5 t CO2 compared to 11.4 t gasoline engine (U.S. Department of Energy, 2017)
	
	Given the EU target of 2030, ensure at least 27 % of renewable energy, the WTW emissions will be even lower (International Energy Agency, 2014).

High Fuel Tax (The Innovation Center for Energy and Transportation, 2011)	• HEV
	  ○ Low mitigation due to combined use of combustion and electric motor
	• PHEV
	  ○ Partial mitigation due to the ability to recharge the battery and not depend only on the internal combustion engine and fossil fuels
	• BEV
	  ○ Exemption from this tax

Incentives (The Innovation Center for Energy and Transportation, 2011)	• Allowing the use of lanes for IRS, bus, etc. • Parking at reduced rates or free of charge • Possibility to park anywhere • Dedicated parking in parking lots at charging stations • Free access to the city center • Contribution to purchase of electric car • Fuel Excise Tax Exemption, Ownership Tax and Commercial Fleet Taxes (European Automobile Manufacturers Association, 2018) • High Income Tax Rate (European Automobile Manufacturers Association, 2018) • Reduced registration tax rate (European Automobile Manufacturers Association, 2018) • Zero Import Tax (2018) • Toll Free Passage (Fearnley, Figenbaum, Jellinek, & Pfaffenbichler, 2015)

10 - Advantages of Electric Vehicles in Light of Legislation Programs

Given the EU's ambitious target of reducing emissions by up to 95% compared to the 1990 level (International Energy Agency, 2014), it will be very important for cities to use any instrument that will help them to achieve this, and it is precisely electromobility in various areas of urban operation that can be one of the most effective.

Planned changes to legislation

One of the biggest interventions in the automotive industry and the market is the ban on the sale of fossil fuel vehicles. Some countries are considering this step in the next few years (Norway is planning to do so in 2025), others have this goal by 2040 (France or the UK).

A less radical step is to achieve a certain ratio of electric vehicles to the total fleet within the country. Whether it is a ratio of electric vehicles or a given number in absolute terms, electromobility is one of the main trends that will dictate the direction of mobility over the next few decades (Partnership on Sustainable Low Carbon, 2018).

Assessment of the development of e-mobility in terms of electricity sources - renewable and non-renewable resources

Electromobility and renewable resources

In order for electric cars to bring real benefits over internal combustion engines, the development of a rechargeable infrastructure requires that at the same time the sources of electricity that these stations recharge are innovated. Moving to renewable energy sources is key to the success of electromobility and reducing environmental burdens (European Climate Foundation, 2017). The basis is therefore to create an energy mix that is not only focused on shifting externalities closer to power plants, but to reduce emissions both for vehicles and power plants (Energynautics GmbH, 2017). If the energy mix were not updated, electric cars would not be as attractive to users or politicians as they would merely move emissions from place to place without striving to reduce them (Mittal, 2018).

However, with the outlook provided by the International Energy Agency (IEA), it is clear that the use of renewables is unavoidable as it estimates that within 4 years renewable electricity will account for 30% of the total. It also estimates that by the end of the next decade, the number of electric vehicles will increase to hundreds of millions. This combination of the development of electromobility and the shifting of the energy mix to renewable resources could be essential steps to reduce emissions and the negative impact of transport on ecology (Mittal, 2018).

An important aspect of electromobility from renewable sources is also independence from fossil fuel supplies, making electromobility a sustainable mode of transport that is not dependent on conditions created in other areas. So the benefits are not purely ecological, but also political and economic, with a positive impact on living in an urban environment. (Albanese, Ciriminna, Meneguzzo, & Pagliaro, 2015).

Electromobility and Energy Network

Electric vehicles have a double effect on the energy network

- It serves as a device that draws electricity from the network
- They can be used as temporary batteries to store or return power to the network

As for the first point, in order for the network to be able to accommodate the fluctuations caused by the increase in the number of electric vehicles, it is necessary to adapt the network itself with a smart grid approach. As far as low voltage is concerned, the control systems that regulate the network structure will be an essential part of the operation of the power grid (VERBUND, 2014), as it will change into a flexible network that will not only be able to work with the surge, but will also be able to use the wired as a temporary resource to balance offtake.

This approach is called a vehicle-to-grid (V2G) and uses the fact that electric vehicles are connected to the network even when they are not charging themselves, but have a charged

battery in stock (ENEL, 2017). Electric vehicles can help the electricity network improve quality, create external storage and increase the share of renewable sources in electricity generation (Institute of Electric Energy Systems and High Voltage Technology).

Emissions that are generated throughout the fuel cycle are recorded in two steps. First, it is the acquisition and distribution itself to the final distribution point. Furthermore, it is then self-burning within the car. Electric vehicles have zero in this second phase of emissions, but in terms of electricity generation, emissions depend on the type of raw material from which the electricity is generated. The more renewable energies are included in the energy mix, the less environmental impact is.

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